STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

INSTRUMENTATION INSTALLATION FOR EXPOSITION BOULEVARD OVERHEAD

October 1963

63-11

State of California
Department of Public Works
Division of Highways
Materials and Research Department

November 1963

Proj. W. O. R-63294

Mr. J. E. McMahon
Asst. State Hwy. Engr.--Bridges
California Division of Highways
Sacramento, California

Attention: Mr. J. J. Kozak

Dear Sir:

Submitted for your consideration is a report of:

INSTRUMENTATION INSTALLATION

FOR EXPOSITION BOULEVARD OVERHEAD

Instrumentation performed by . . . Structural Materials Section
Under direction of . . . . E. F. Nordlin
Work supervised by . . . . J. E. Barton and W. Chow
Report prepared by . . . . W. Chow

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

WC:mw

INTRODUCTION

At the request of the Bridge Department, the Materials and Research Department instrumented Exposition Boulevard Overhead for a series of tests on the research tendons. The test work was performed to acquire more complete information on the actual stress values and stress losses in post-tensioning tendons of the above-mentioned overcrossing.

The overhead is a continuous prestressed concrete box girder structure approximately 354 feet long consisting of three spans and supported on four bent caps and piers and providing a clear roadway width of 28 feet. The bridge (Br. No. 53-704(OL) is located in the city of Los Angeles on Route 173 between 0.3 mile west of Sawtelle Boulevard and Overland Avenue; and on Route 158 between 0.4 mile south of National Boulevard and 0.2 mile north of Pico Boulevard, VII-LA-173-LA. Figure 1 is a view of the overhead during the construction phase.

The instrumentation was installed concurrently with the construction of the structure under Contract 63-7V13C62. Contract special provisions provided for this test work. Instrumentation installation was divided into two phases. Phase #1 consisted of the period between the time when all bottom soffit reinforcing steel bars, stem reinforcing steel bars, and all tendons were in place and before soffit and stem concrete was placed. The Phase #1 period was used to install 66 strain gages on various research tendons, place compensation gages, hook up extension cables, and to install four prestrain gaged reinforcing steel bars. Phase #2 was utilized to route the strain gage cables inside the deck forms, to strategically locate the conduit outlet boxes in the curb and to place two strain gaged #4 reinforcing steel bars, prior to concrete placement.

Phase #1 was started on May 20, 1963, and completed on May 27, 1963. A total of 264 man-hours were utilized for Phase #1. The concrete for the soffit and girder stems was placed on June 11. Phase #2 was started on June 12 and completed on June 26. A total of 30 man-hours was utilized for Phase #2. Concrete for the bridge deck was placed on June 27.

Testing of the research tendons was started on July 22, 1963, and completed on August 2, 1963. This report covers only the instrumentation installation as performed by the Materials and Research Department.

The test program was under the direction of Bridge Department personnel and pertinent test data, procedure, and information were recorded by them. Laboratory personnel recorded all strain gage and jacking load data. This information has been turned over to the Bridge Department for their analysis.

SR-4 STRAIN GAGE INSTALLATION ON RESEARCH TENDONS

Post-tensioning strains in the research tendons were measured with Baldwin FAN-12-S6L SR-4 strain gages. The gage, Figure 2, consists of a thin metal foil 0.25" long by 0.02" wide on an epoxy carrier. The epoxy carrier serves as protection for handling ease and as an insulator when bonded to a metal surface. The gages were self-temperature compensated gages with an expansion coefficient of 6 parts per million per ^{o}F. to compensate for steel expansion.

To measure strains the metal foil gage was cemented to the tendon in question. The strain gage operates on the principle that the electrical resistance of the gage varies with strain. In order to make use of the gage, it must be connected to a resistance measuring device. The instruments used to measure static strains throughout this test with these gages were Baldwin Type M strain indicators.

The overhead was a post-tensioned structure with 10 research tendons out of a total of 38 tendons. Eight of the tendons were encased in a flexible continuous length metal sheath while the remaining 2 tendons were encased in 20 foot lengths of pipe tubing. Figure 3 lists the various types of tendons in the different types of encasement. Figure 3-A shows the research tendons in relation to the other tendons.

Before the strain gages could be installed on the tendons, a portion of the sheath or tubing had to be removed. Eighteen lineal inches of sheath or tubing were removed at each gage location, thus exposing the research tendons. Figure 4 shows the sheath removed from research tendons #5 and #6, exposing the Freyssinet cables. All sheaths were cut with tin snips while the two pipe tubings were cut with a 4 wheel Rigid pipe cutter. The pipe tubing at research tendon #1 at the centerline of the bridge span could not be cut because of its inaccessible location and thus no strain gages were installed on this tendon at the centerline. Figure 5 shows the inaccessible location and the uncut pipe tubing. See Figure 3-A for research tendon numbering system and gage locations.

Two gages were installed at each gage location, one gage being the "back up" gage. On the Roebling tendons and the 40 wire BBRV tendons, the "main" gage and the back-up gage were installed on different wires of the tendons. The Freyssinet tendons consisted of 12 one-half inch strands. On the Freyssinet tendons both gages were installed on the same strand but on different wires of the strand. Each Freyssinet strand consisted of 7 wires.

Prior to the actual gluing of the gage each wire location was sanded with #180 silicon carbide paper to remove rust or zinc coatings. Each wire was then rigorously cleaned and degreased with a cheesecloth soaked in acetone. This procedure was repeated until an acetone-soaked cheesecloth came away clean after wiping the gage area.

All gages were glued to the tendon wires with Baldwin EPY-150 epoxy cement. The cement was applied in a thin layer to the back of the gage and to the prepared wire surface. The gages were placed on top of the cement and carefully aligned. Excess cement was squeezed out with a rolling motion of the thumb and the gage realigned. A piece of cellophane tape was then wrapped around on top of the strain gages and the wire or tendon to maintain their alignment. Several strands of rubber bands were then wrapped around and stretched on top of the cellophane tape. The rubber bands served to maintain a constant pressure on the gages during the curing cycle and the tape maintained the gage alignment.

Insulated thin copper terminals were also glued alongside of the ends of each strain gage. The copper terminals served as terminations for joining the strain gage lead-out wire and the hookup extension cable. The curing cycle for the cement-gage-terminals combination consisted of approximately 4 hours under several 250 watt infrared heat lamps. The lamps were placed 12 to 14 inches from the gage. Figure 6 shows a completed gage and terminal installation being cured by the heat lamps.

The gages were now ready to be electrically wired with hookup-extension cable. The hookup-extension cable used was Belden #8434 strain gage cable. The 8434 cable consists of four conductors color coded black, white, red, and green. The black and white conductor pair was always used to hook up one strain gage, and the red and green conductor pair was always used to hook up the backup strain gage. Figure 7 shows the over-all gaging operation at the bridge centerline.

The next step was to protect the strain gage and surrounding area from moisture and mechanical damage. An epoxy type waterproofing material was chosen for the job. All #8434 cable ends that were attached to the strain gages were wiped with a MIBK chemical solution. The solution increased the adherence of the epoxy waterproofing to the cable.

The waterproofing epoxy was a two part epoxy-Thiokol mixture purchased from Mark-A-Line, Inc., 95 Gage 5 Road, Sausalito, California. It consisted of two separately bulk packaged mixtures of the following composition by weight:

Mixture #1:	Shell Epon Resin 828	91.0%
	Cab-O-Sil, Uncompressed	8.0%
Mixture #2:	Thiokol LP-3	86.8%
	DMP-30	5.1%
	Cab-O-Sil, Uncompressed	8.1%

One part by weight of Mixture #1 was mixed with two parts by weight of Mixture #2. The mixture in its uncured stage is like a heavy grease paste and does not sag. It cures to a solid elastic material. The uncured mixture was applied over the completed wired-up gage installation and the surrounding area with a wooden tongue blade. Extra care was made to insure that the mixture completely surrounded the connecting #8434 cable. Figure 5 shows a completed mixture installation on a Freyssinet tendon.

After the epoxy-Thiokol mixture had cured overnight, a black colored liquid synthetic rubber was brushed over the mixture. The liquid rubber, RC-9, acted as a surface sealer and was manufactured by Heresite & Chemical Company of Manitowoc, Wisconsin. Figure 8 shows a completed Roebling tendon installation with the black synthetic rubber covering the epoxy-Thiokol mixture.

The last procedure was to re-encase the exposed tendons with stove pipes. The stove pipes were 4" in diameter by 24" long. Figure 9 shows a stove pipe ready to be encased around a Freyssinet tendon. A hole was drilled in each stove pipe so that the strain gage cable could be passed through the stove pipe prior to encasement. Each end of the stove pipe was closed off with sheet metal caps and taped to prevent grout leakage during the concrete placement. Figure 10 shows the completed installation at the bridge half span point.

Eight compensation "dummy" gages were made in the laboratory for installation in the concrete girder stems. Each "dummy" gage consisted of a FAN-12-S6L strain gage attached to a 5" length of #6 reinforcing steel. The reinforcing steel was then placed into a steel tube, longer than the reinforcing steel, with a suitable length of cable attached to the gage coming out of the steel tube. Ends of the tube were sealed with epoxy. The strain gaged reinforcing steel was thus free to thermally expand or contract unrestrained inside of the tube.

The dummy gage formed a part of the Wheatstone electrical bridge circuit used in statically reading all of the strain gages.

The dummy gage also served to cancel out false strain changes due to temperature changes. This is because strain gages are sensitive to temperature changes as well as strain changes.

STRAIN GAGED #4 REINFORCING STEEL

Web stresses in the center girder stem at bent 15 were measured by FAN-12-S6L strain gages installed on six 5 foot lengths of #4 reinforcing steel. Three strain gages were installed on each of the six lengths of reinforcing steel. Figure 11 shows the placement of the reinforcing steel and gage locations on the reinforcing steel.

All of the strain gages on the reinforcing steel were premounted in the laboratory complete with extension cables and waterproofing. The same general method was used in the reinforcing steel gage installation as was previously described for gage installation on the research tendons.

Four reinforcing steel bars, with gage numbers #1 through #12, were installed in the girder stems during Phase #1. Stove pipes were not used with the steel bar installations. Extension cables were routed over to conduit boxes, Figure 12, in the same manner as was for the research tendon cables.

During Phase #2 the remaining two reinforcing steel bars were placed in the top slab and their cables routed into conduit boxes prior to the deck pour.

TESTING OF THE RESEARCH TENDONS

Testing of the 10 research tendons started after stressing of the 28 non-research tendons had been completed.

Research tendons #5 and #6 were stressed in approximately equal steps to 341 kips from both ends. The stressing loads were measured at each end with laboratory-built load cells.

Strain data on tendons #5 and #6 after stressing were recorded daily, morning and evening, for two weeks until completion of the research tendon testing.

The other eight research tendons were stressed in the same manner but released after reaching stress load. These tendons were "saved" for later restressing with different lubricants in the grout tubes.

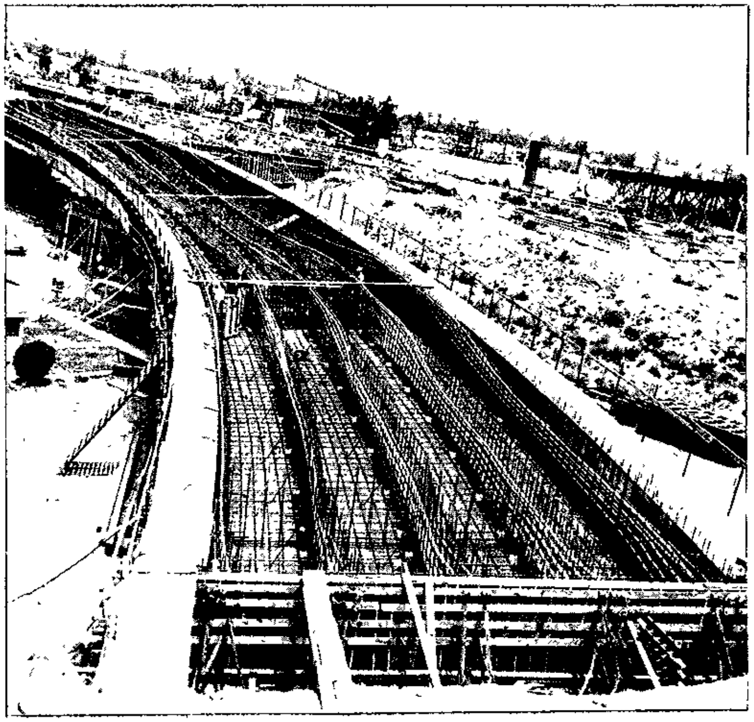


FIGURE 1

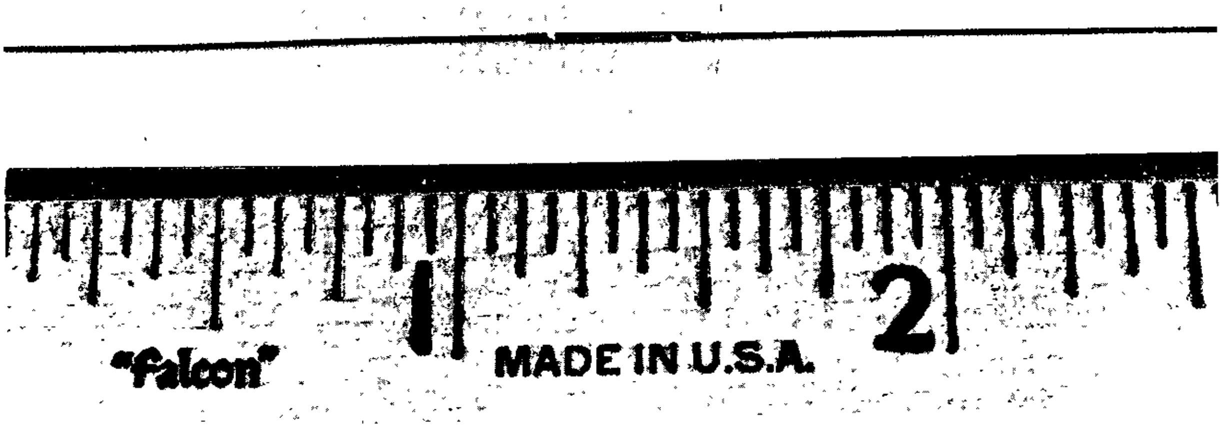


FIGURE 2

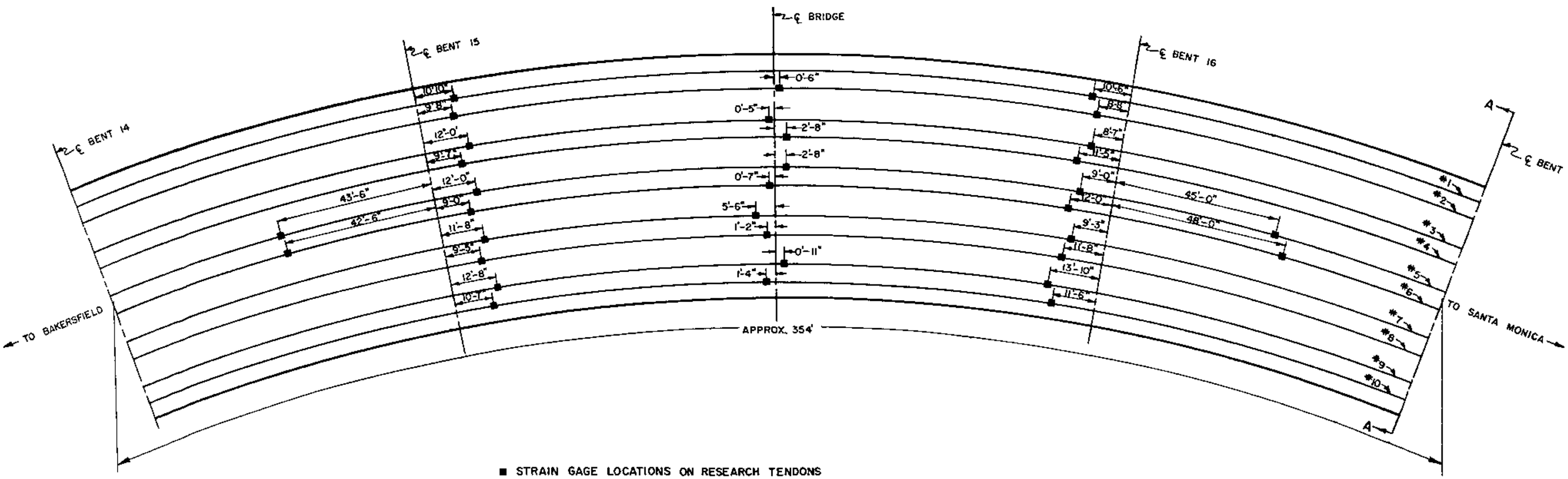
LIST OF EXPOSITION OVERCROSSING RESEARCH TENDONS

Tendon Number	Tendon	Sheath
1	40-wire BBRV, galvanized wire	Bright thin wall metal tubing
2	12 ½" strand Freyssinet	Galvanized metal
3	40-wire BBRV, galvanized wire	Galvanized metal
4	12 ½" strand Freyssinet	Bright metal
5	12 ½" strand Freyssinet	Bright metal
6	12 ½" strand Freyssinet	Galvanized metal
7	40-wire BBRV, bright metal	Bright metal
8	1-11/16" Roebling preformed wire strand	Galvanized metal
9	40-wire BBRV, bright wire	Galvanized thin wall metal tubing
10	1-11/16" Roebling preformed wire strand	Bright metal

EXPOSITION BOULEVARD OVERHEAD

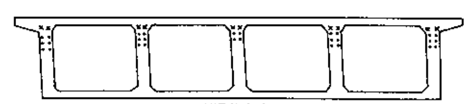
ROAD VII-LA-173-LA

Sta. 232+39 to Sta. 235+93



■ STRAIN GAGE LOCATIONS ON RESEARCH TENDONS
SCALE: NONE

TENDON No.	TENDON TYPE
#1	GALVANIZED BBRV IN UNGALVANIZED TUBING
#2, #4, #5, #6	FREYSSINET IN SHEATH
#3	GALVANIZED BBRV IN SHEATH
#7	UNGALVANIZED BBRV IN SHEATH
#8	GALVANIZED ROEBLING IN SHEATH
#9	UNGALVANIZED BBRV IN GALVANIZED TUBING
#10	GALVANIZED ROEBLING IN SMALL SHEATH



VIEW A-A
x - RESEARCH TENDONS
· - NON-RESEARCH TENDONS

Figure 3A

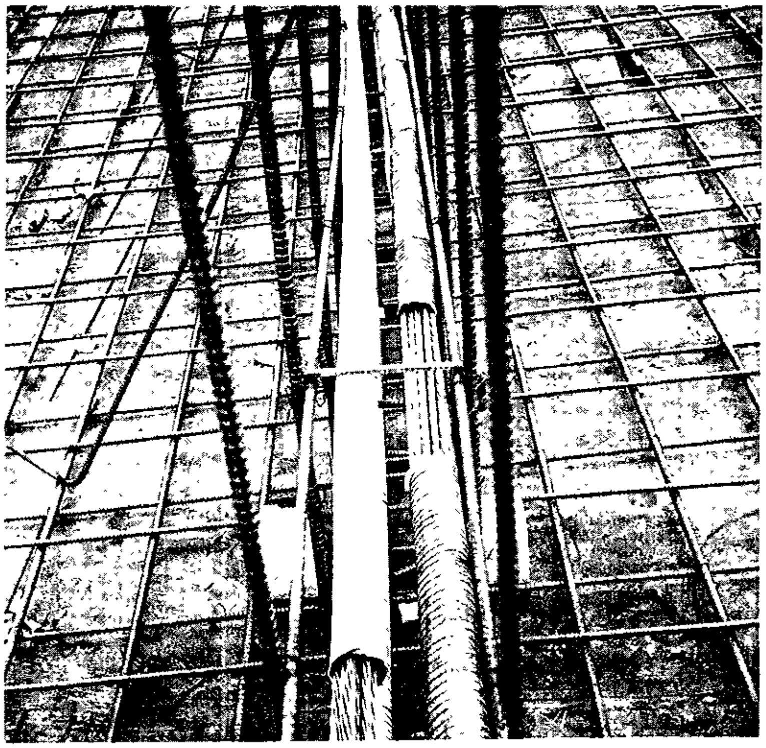


FIGURE 4

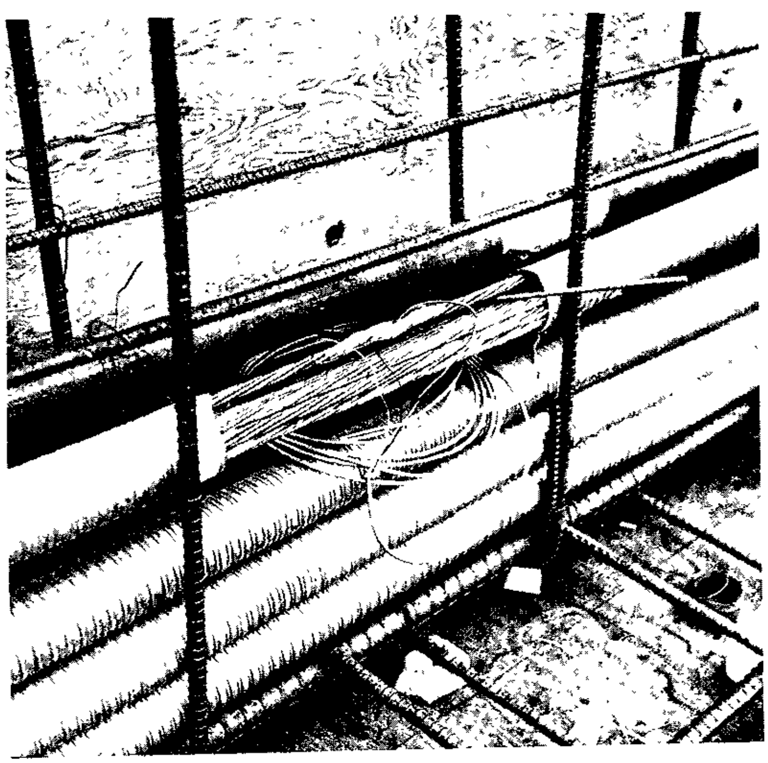


FIGURE 5

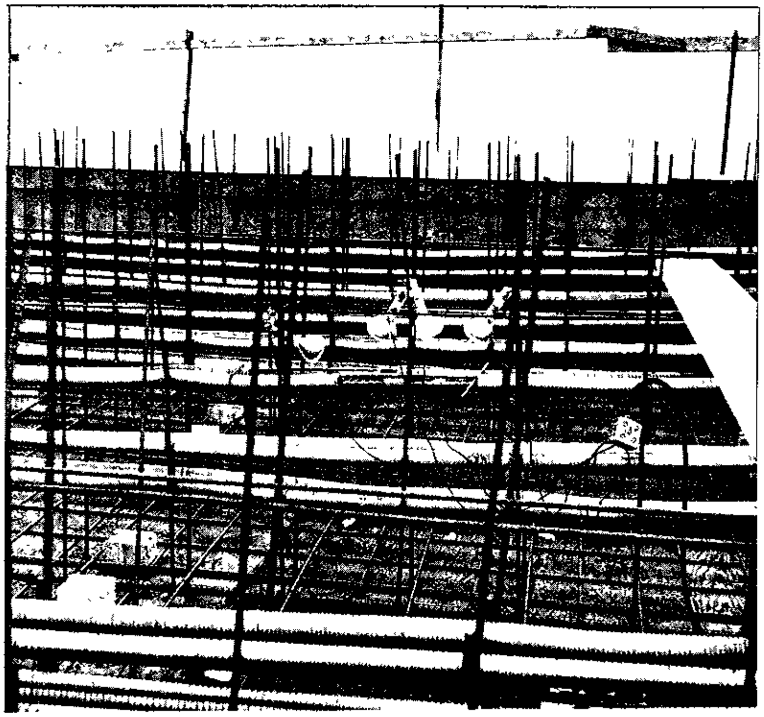


FIGURE 6

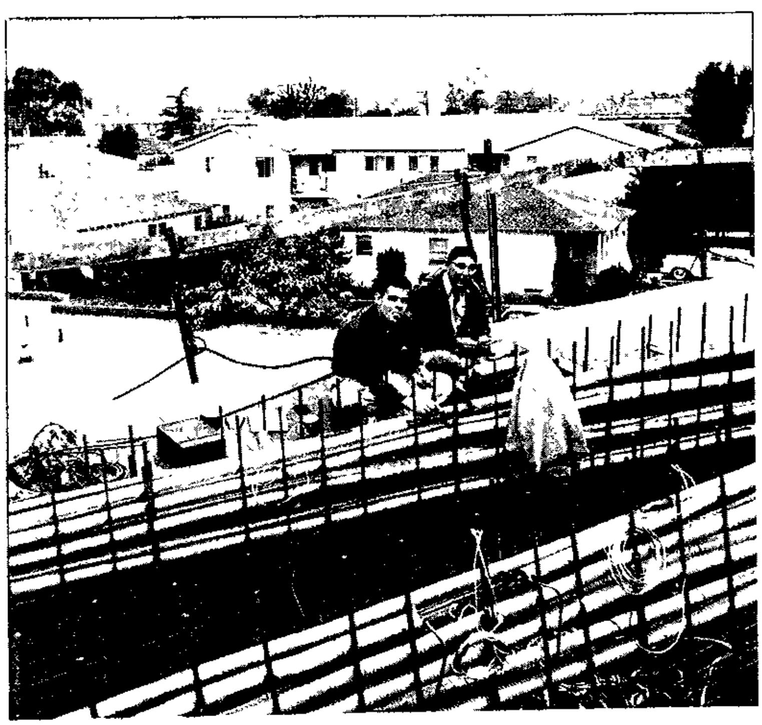


FIGURE 7

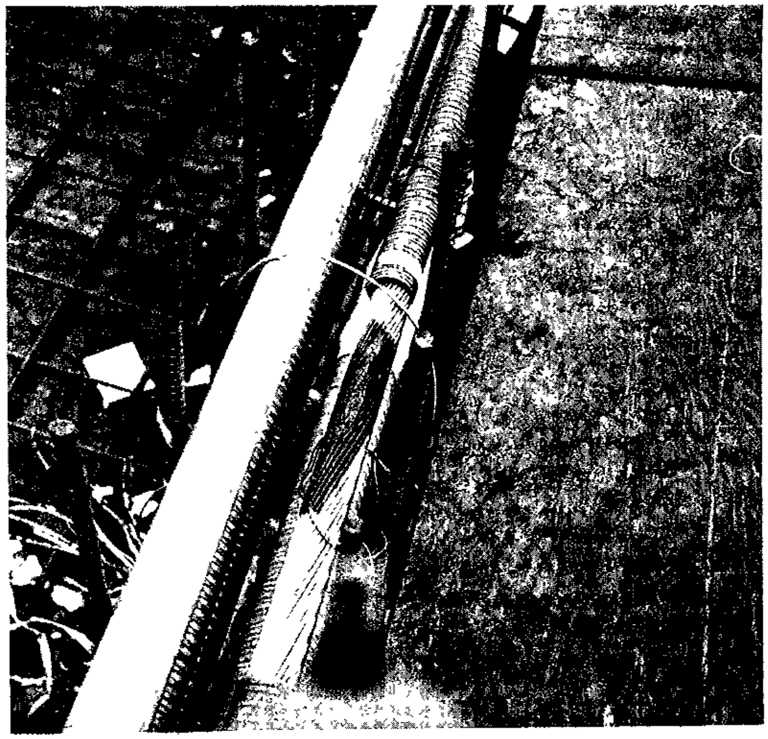


FIGURE 8

FIGURE 9

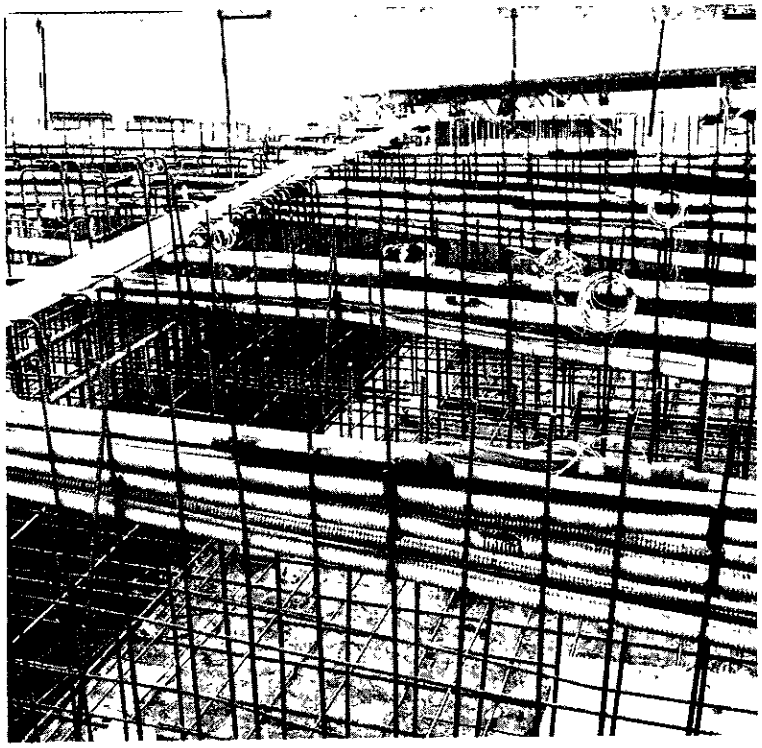
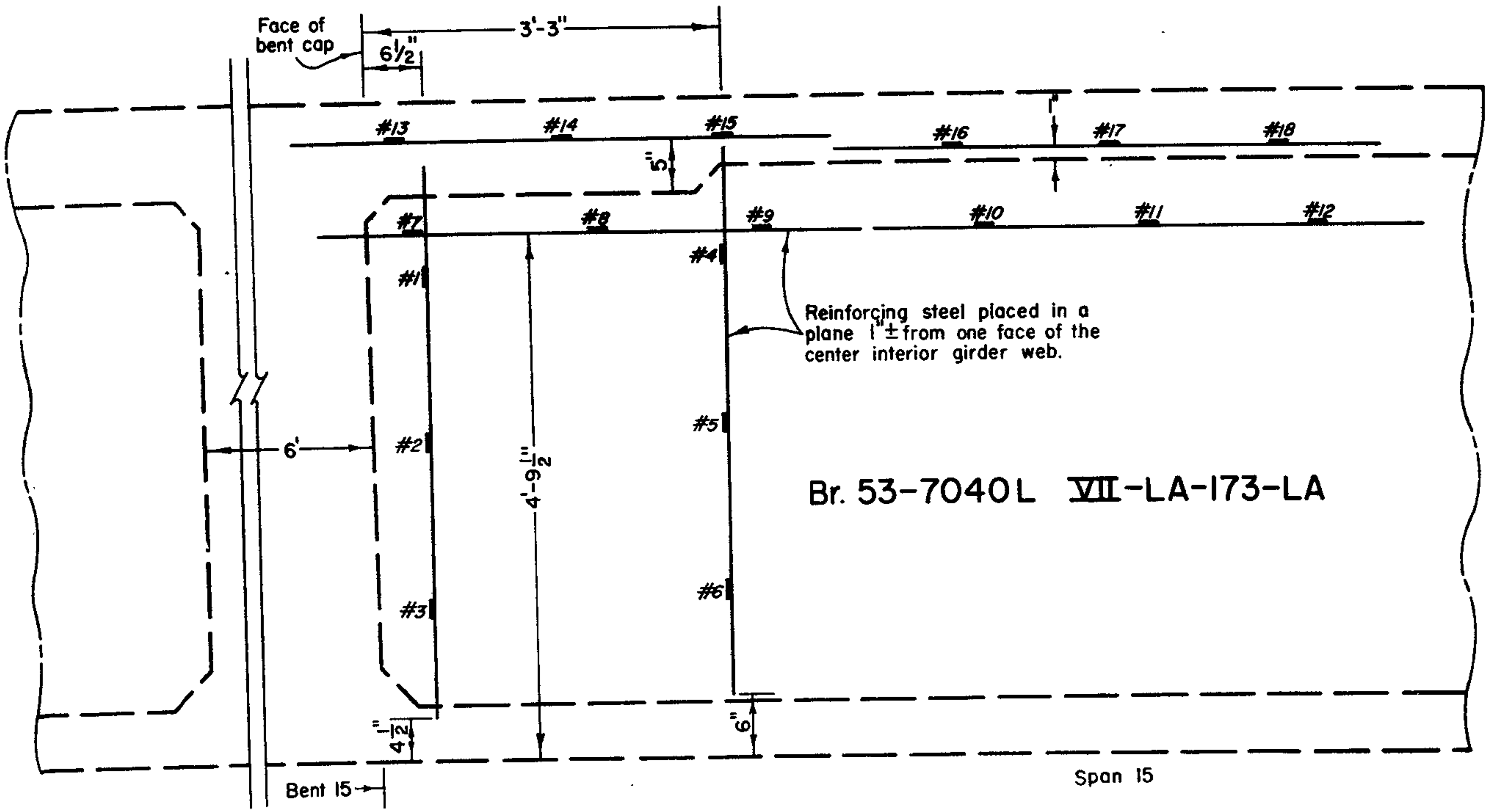


FIGURE 10

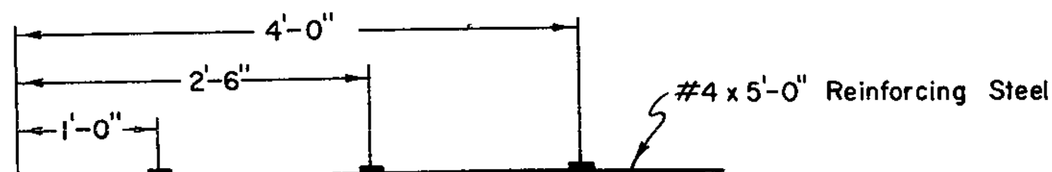
Figure 11

EXPOSITION BOULEVARD OVERHEAD

Location of strain gages for web stress measurements



Scale: $\frac{3}{4}$" = 1'-0"



Typical strain gage layout.

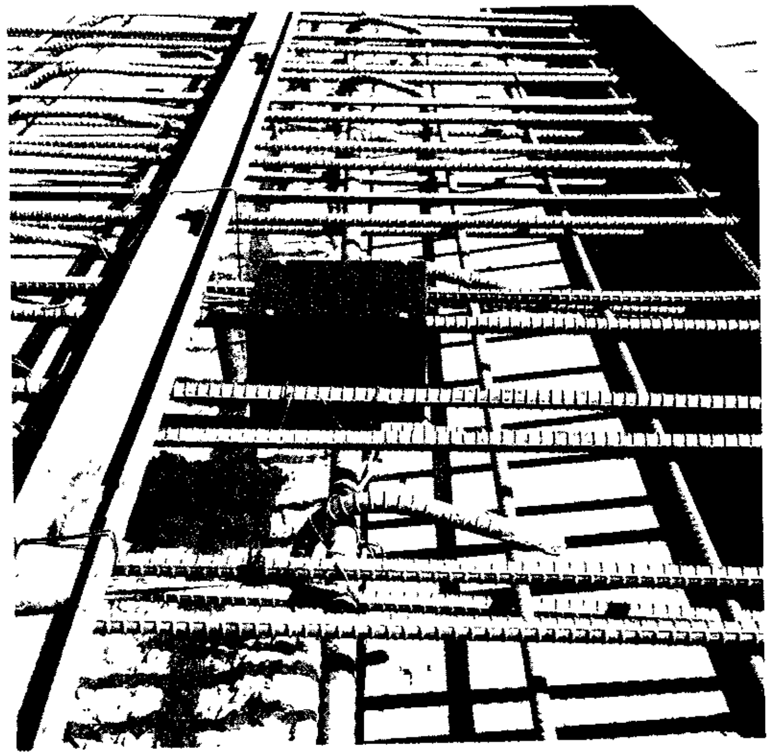


FIGURE 12